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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
Washington

Letter Circular LC-556

(June 21, 1939)

AUTOMOTIVE BRAKE LINING

CONTENTS

I. INTRODUCTION

This letter circular has been prepared to give the consumer general information regarding the brakes of an automobile and to show the characteristics which brake linings should have in order that the brakes may operate safely, uniformly, and efficiently. The modern brakes are so complex that no single lining is the best for all purposes; in fact a single brake may require two different types of lining in different positions. Linings should be selected so as to have a coefficient of friction suitable for the particular brake and place in the brake in which they are to be used. Furthermore, they should maintain these frictional characteristics under all ordinary operating conditions, so that the same pedal pressure may produce the same deceleration regardless of the temperature, the presence or absence of moisture, the age of the lining, or other circumstances. While wear is no longer the major problem it once was, the rate of wear should obviously be kept as low as may be consistent with satisfactory performance since the cost of replacing worn linings and the attendant loss of use of the vehicle represent a much greater expense than the actual cost of the material.

The stopping of a car is limited, in the final analysis, by the coefficient of friction between the tires and the road surface. Brakes can retard the action of the wheels up to the point where they slide on the road, but beyond this they can have no effect. Assuming a coefficient of friction between the tires and the road of 0.8, which is close to the upper limit, a car can lose speed at the rate of 25 ft. per second per second, or in more familiar terms, about 17 miles per hour per second. Thus, from a speed of 34 miles per hour it could be stopped in about two seconds. Under average conditions the coefficient of friction will be less than 0.8 and the possible retardation correspondingly less. In any case, it should be possible for the driver to control the retardation easily and the pedal force required should be within reasonable limits.

II. TYPES OF BRAKES

Prior to 1925 most brakes on automobiles were of the external contracting type. These brakes are still used to some extent, especially for shaft or parking brakes, but the internal expanding brake has replaced the external type for most uses. The internal brake is more compact and can be better protected from dirt and water than the external brake. However, it does require that more attention be given to the characteristics of the brake lining used, especially with drums of small diameter.

There are many different kinds of internal brake mechanisms. All of them employ sections of lining riveted or bolted to bands or shoes mounted in various ways so that the lining may be forced against the drum surface. The shoes may be actuated by some mechanical means, or by the use of a hydraulic cylinder. There are some differences in the way in which a brake operates, depending on whether it is mechanical or hydraulic, but for purposes of this discussion it is simply considered that forces are applied to the shoes or bands by some appropriate means.

Figures 1 to 4 illustrate some typical brake mechanisms and show the way in which the braking forces act in retarding the movement of the brake drum and in turn of the automobile. Parts which are unessential from the standpoint of braking action, such as retracting springs and means for adjustment, have been omitted.

All brake mechanisms illustrated are designed so that they are self-energizing to some degree in that rotation of the brake drum while the brake is applied affects the pressure between the lining and the drum. The energization is not the same for all brakes nor for different shoes in any one brake. The object of energization is to make less effort necessary in applying the brakes without loss in braking ability. Due to energization many brakes perform differently depending on whether the car is moving in the forward or the backward direction.

The energization is due to the frictional force of the brake drum on the brake lining. This force when considered in connection with any one shoe may tend to force it either toward or away from the drum and will have the effect of either adding to or subtracting from the force (F) shown in the figures. The amount of energization has an important bearing on the selection of the most suitable lining for a particular brake shoe.

The features to be noted in the brake mechanisms shown in figures 1 to 4 are

(1) Location of the anchor pin;

(2) The connections, if any, between shoes;

(3) The layout of any linkages used.

Referring to figure 1, the forces (F) act at the ends of the bands and as the drum turns frictional forces are set up which tend to force the top half of the lining toward the drum and the lower half away from the drum. Thus, it will be found that forces normal to the drum and hence the retarding forces vary along the length of the band from a high value at point C to a low value at E with intermediate values at B and D. By locating the anchor pin at other positions on the circumference of the band, the relative values of these forces can be changed.

Figure 2 illustrates a simple type of internal brake mechanism. The shoes are rigid; both are anchored at A and forces are applied at F to bring the lining in contact with the drum. Shoe (a) is energized inasmuch as frictional forces tend to force it toward the drum. Shoe (b) is de-energized inasmuch as frictional forces tend to force it away from the drum. The amount of energization depends on the location of the anchors relative to the braking surface.

Figure 3 illustrates a brake similar to figure 2 except that links are used to connect the shoes to fixed anchors, thus allowing the shoes more freedom to adjust themselves to the drum. Energization can be varied considerably by different arrangements of the linkages and the anchor pins. Two arrangements are indicated in the figure. If links are placed as shown at (G) the energization on shoe (a) and the de-energization on shoe (b) will be greater than if they are placed at (H). In the brakes shown in figures 2 and 3 it will be noted that each shoe operates independently.

In figure 4 the two shoes are connected by a link at the bottom and anchors are provided at the top. In this brake energization takes place to some extent in shoe (a) because shoe (b) acts as an anchor. Shoe (b) is also energized on account of the direction of rotation and the location of the anchor. Also, there is an additional effect in that the force on the end of shoe (b) is dependent on the total frictional force of shoe (a).

There are many modifications of these brakes. Shoes of different types or of different lengths are often employed in the same brake. Sometimes a flexible band is substituted for one or both of the shoes. Three or four shoes are sometimes employed in the same brake, but the two shoe brake, with rigid shoes, is the most common type.

As a result of the energization of brakes it will be evident that although the lining operates inside a smooth cylindrical drum and presses against a large part of the drum surface, there is far from uniform braking action along the lining. One lining, or a portion of one lining, may do a major part of the work.

The figures showing brake mechanisms and the statements made relative to their action are all based on the movement of the car in the forward direction. Brakes are also required when a car moves in the reverse direction, but in most cases a less efficient brake is satisfactory for backward motion, and the effectiveness may be sacrificed for better operation in the forward direction.

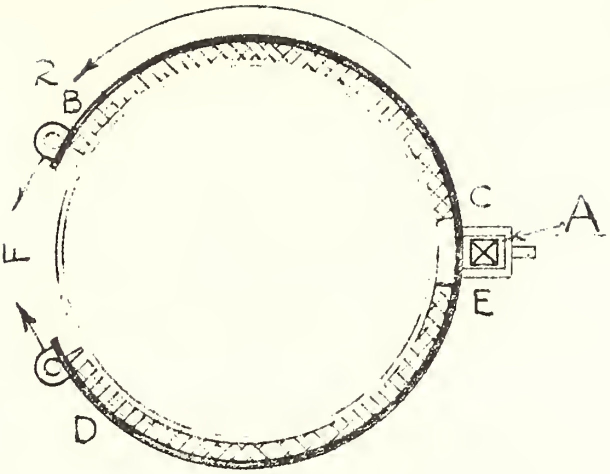

Fig 1

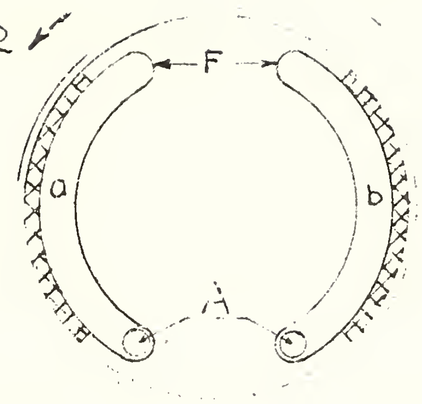

Fig 2

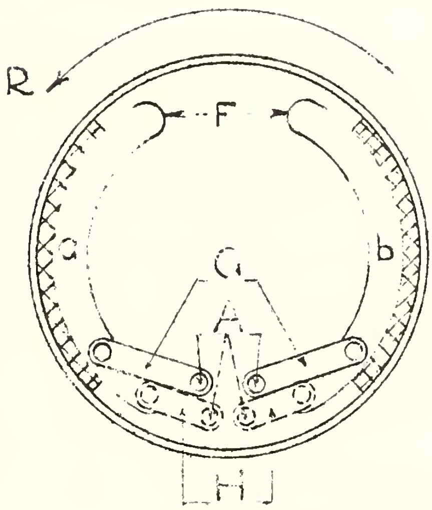

Fig 3

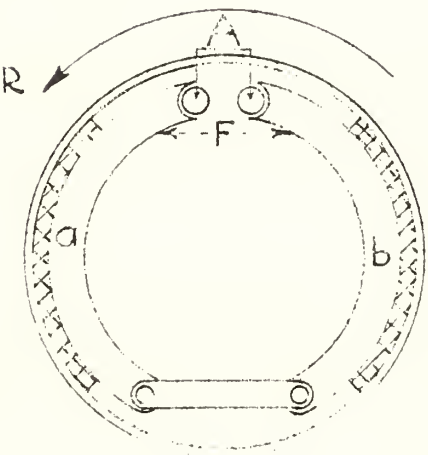

Fig 4

TYPICAL BRAKE MECHANISMS

Legend

R - Forward direction of arum rotation
F - Point of force application
A - Anchor pins

III. ADAPTING BRAKE LININGS TO BRAKES

The force which the driver of a car is required to exert on the brake pedal in order to produce a desired deceleration of the car is dependent on the linkage between the brake pedal and the brake, friction losses, the energizing action of the brake mechanism, and the coefficient of friction between the lining and the drum. From this it would seem that linings having a high coefficient of friction and large energizing effects would be the most desirable for a brake. Such is probably the case <u>if these factors can be adequately controlled</u>. From a practical standpoint, however, there are limits to this control and hence limits to the amount of energization which can be utilized and to the value of the coefficient of friction which can be employed. The more energization incorporated into a brake shoe mechanism the more necessary it is that the friction of the lining be correct and that it be maintained at the correct value. For instance, high friction linings or those which develop high friction under certain conditions will cause highly energized brake shoes to "grab". Low friction linings on brake shoes which have little or no energization may require a large force on the brake pedal. Neither condition is satisfactory.

In order for a brake to operate in the most efficient manner, the frictional characteristics of the lining should be suited to the brake mechanism on which it is used. In addition, the braking action should be distributed over as large an area of the lining and in as uniform a manner as is practicable. Such distribution will tend toward uniform braking under different conditions and a minimum rate of wear.

Several steps or combinations of steps may be taken in order to accomplish the desired distribution of braking action and wear:

(1) Different types of shoe mechanisms may be combined in a brake,

(2) Different lengths of shoes may be used,

(3) In order to promote uniform wear over the whole area of lining, a faster wearing lining may be used on the shoe doing the less work,

(4) Stepped cylinders may be used in hydraulically operated brakes, so that a greater force is exerted on one shoe than on the other,

(5) Linings with different frictional characteristics may be used on different shoes.

The fifth procedure is practically a necessity in the case of some brakes and is desirable with many.

A general rule to follow in selecting a brake lining for a brake shoe is that <u>an energized shoe requires a low or medium friction lining and a de-energized shoe requires a medium or high friction lining</u>.

According to this rule the following kinds of lining would be selected for the brakes shown in figures 1 to 4.

Figure 1. High friction on bottom, and medium friction on top. However, the uses for this brake are quite limited, the energization is comparatively small, and it is common practice to use a high friction lining all around.

Figure 2. Medium friction on shoe (a), and high friction on shoe (b).

Figure 3. Low, medium, or high friction on shoe (a) depending on the location of the links, high friction on shoe (b).

Figure 4. Medium friction on shoe (a), low friction on shoe (b).

IV. CONSTRUCTION OF BRAKE LININGS AS RELATED TO PROPERTIES

Three different types of lining are often referred to — woven, folded and compressed, and molded. The essential difference is that the first two are made with either asbestos cord or cloth as a base, while the third is made with loose fibre as a base. All three types contain impregnating, binding, and filling materials which may vary greatly both in amount and in kind. The different types may be made flexible so that they can be adapted to any size of brake drum, or they may be made rigid so as to fit one size only. The type of construction or the degree of rigidity, however, do not

determine the frictional characteristics. There is no agreement in the industry that one type of brake lining is necessarily superior to another, but a few general statements can be made as to the characteristics that may be expected.

Molded lining can be made with a greater range of compositions than is possible with the other types and more uniform frictional characteristics are possible -- though are not always attained.

Linings having a very low coefficient of friction are practically always of the molded type.

For average use all types can be made with about equal resistance to wear, but as noted in section VI, woven, or folded and compressed linings are superior for certain types of service.

On the whole, the quality is probably more important than the type.

V. COEFFICIENT OF FRICTION OF BRAKE LININGS

In the previous discussion reference has been made to linings having low, medium, and high coefficients of friction. The industry is not in complete agreement as to the lines of demarcation between these classes, or as to the method of measuring the coefficient of friction. In general, a coefficient of friction between 0.20 and 0.30 is considered low, between 0.30 and 0.40, medium, and above 0.40, high. The difficulty of grouping linings in these apparently simple classes is that even the best linings may show a variation in coefficient of friction of 0.10 for different conditions, so there may be considerable overlapping. Furthermore, in rating linings where such a variation occurs, it is not always clear as to whether the rating is based on minimum, maximum, or average values.

Variations in the coefficient of friction may result especially from two extreme conditions to which linings may be subjected in service, (1) moisture, and (2) high temperatures resulting from frictional heat.

It appears that none of the usual types of brake lining will hold satisfactorily if the brake is flooded with water; that is, the coefficient of friction may drop to perhaps 0.10 or even lower. On the other hand, a very small amount

of moisture will cause many linings to "grab", due to a temporary rise in the coefficient of friction -- sometimes to a value as high as 0.60. Although the best linings will lose friction when flooded with water they will recover quickly as they dry and will show little, if any, tendency for the coefficient of friction to rise above a normal value.

The loss of friction of lining at high temperatures is commonly referred to as "fading". It is generally considered that any lining will "fade" if the temperature is sufficiently high. A good lining, however, will stand temperatures up to 350° F, as measured on the surface of the brake drum, without fading. Many linings will stand 500° F or more. Some types of lining have a tendency to increase in coefficient of friction with a moderate rise of temperature, and some to decrease. By combining such linings on the shoes of the same brake a more uniform action may result than would be indicated by the variation in friction of the individual linings.

VI. WEARING QUALITIES OF BRAKE LININGS

A good brake lining might be defined as one with the desired frictional characteristics together with a low rate of wear. Many linings are available which meet these requirements under ideal conditions but the actual rate of wear is dependent on other things than the lining itself. For instance, a scored drum will produce rapid wear of the lining. Even a drum that has been newly turned or ground may show rapid wear at first. For minimum wear the brake drum should be polished to a mirror finish. High drum temperatures, also, will usually result in a much increased rate of wear. If mud and grit accumulate in the brake drum an abnormally high rate of wear often results. In some parts of the country this condition exists to such an extent that it is usually recommended that all linings be of the woven or folded type, regardless of other characteristics. A lining of this kind apparently permits the particles of grit to accumulate in the interstices of the fabric instead of cutting into it.

VII. PURCHASE OF BRAKE LININGS

The car manufacturer usually buys his brake linings on quite rigid specifications and requires that a given force applied to the brake pedal shall produce the desired deceleration of the car, and that this deceleration shall not be adversely affected by conditions under which the automobile may be operated. In replacing brake linings it should obviously be the aim to use those linings which will give the car the same braking action which it had initially.

The question naturally arises as to how the consumer can determine what kind of lining to use on a given brake. Most of the important manufacturers of brake lining market several, or perhaps many, kinds of brake lining intended for different purposes. Accordingly, the name of the manufacturer alone is not sufficient to determine the quality of a lining or the suitability for a particular brake. The characteristics of a lining cannot be determined from the appearance, and linings are not usually labeled in any way intelligible to the layman. Furthermore, the individual car owner is usually not familiar with the type of brake on the car, and it is not always easy to obtain this information. Such being the case, the individual can best deal with the distributor of his particular car, or with a reliable concern which makes a business of relining brakes. Most of the important manufacturers of brake lining put out sets of lining designed to give the best performance on each particular brake.

Large users, on the other hand, may find it advantageous to buy on specification provided means are available for measuring the performance, either in the laboratory or in service.